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(54) **HYDRAULIC VALVE FOR PIVOT MOTOR ADJUSTMENT DEVICE OF A CAMSHAFT**

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F01L 1/344 (2006.01)

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(58) **Field of Classification Search**
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USPC 123/90.17
See application file for complete search history.

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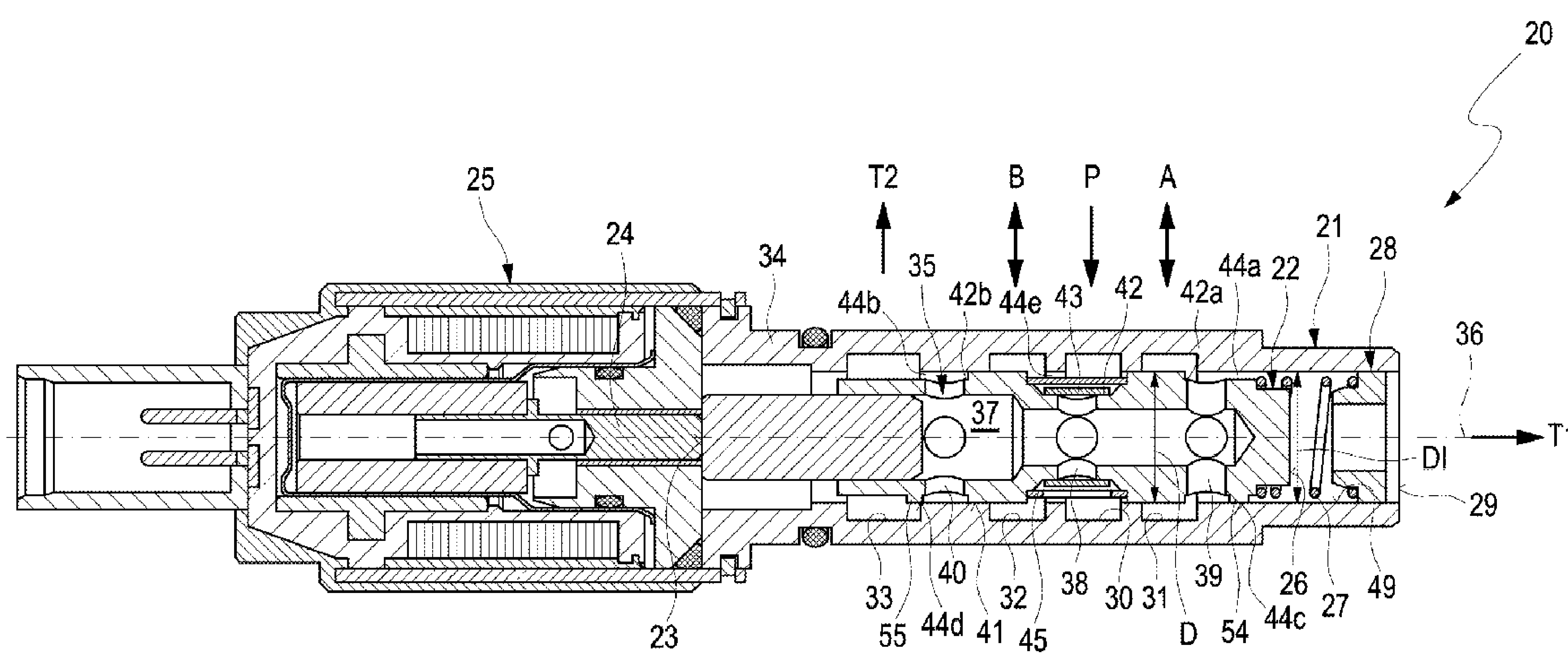
(57) **ABSTRACT**

A hydraulic valve for a pivot motor adjustment device of a camshaft, the hydraulic valve including a valve housing with a longitudinal axis and a valve piston that is axially moveable in the valve housing along the longitudinal axis, wherein a first operating connection of the valve housing and a second operating connection of the valve housing is openable and closable by the valve piston, wherein the first operating connection and the second operating connection are axially offset from one another; and a supply connection of the valve housing, wherein the supply connection supplies the hydraulic valve with hydraulic fluid fed by a feed device, wherein the hydraulic fluid flows through the hydraulic valve on different paths defined by a flowable channel system of the valve piston.

11 Claims, 6 Drawing Sheets



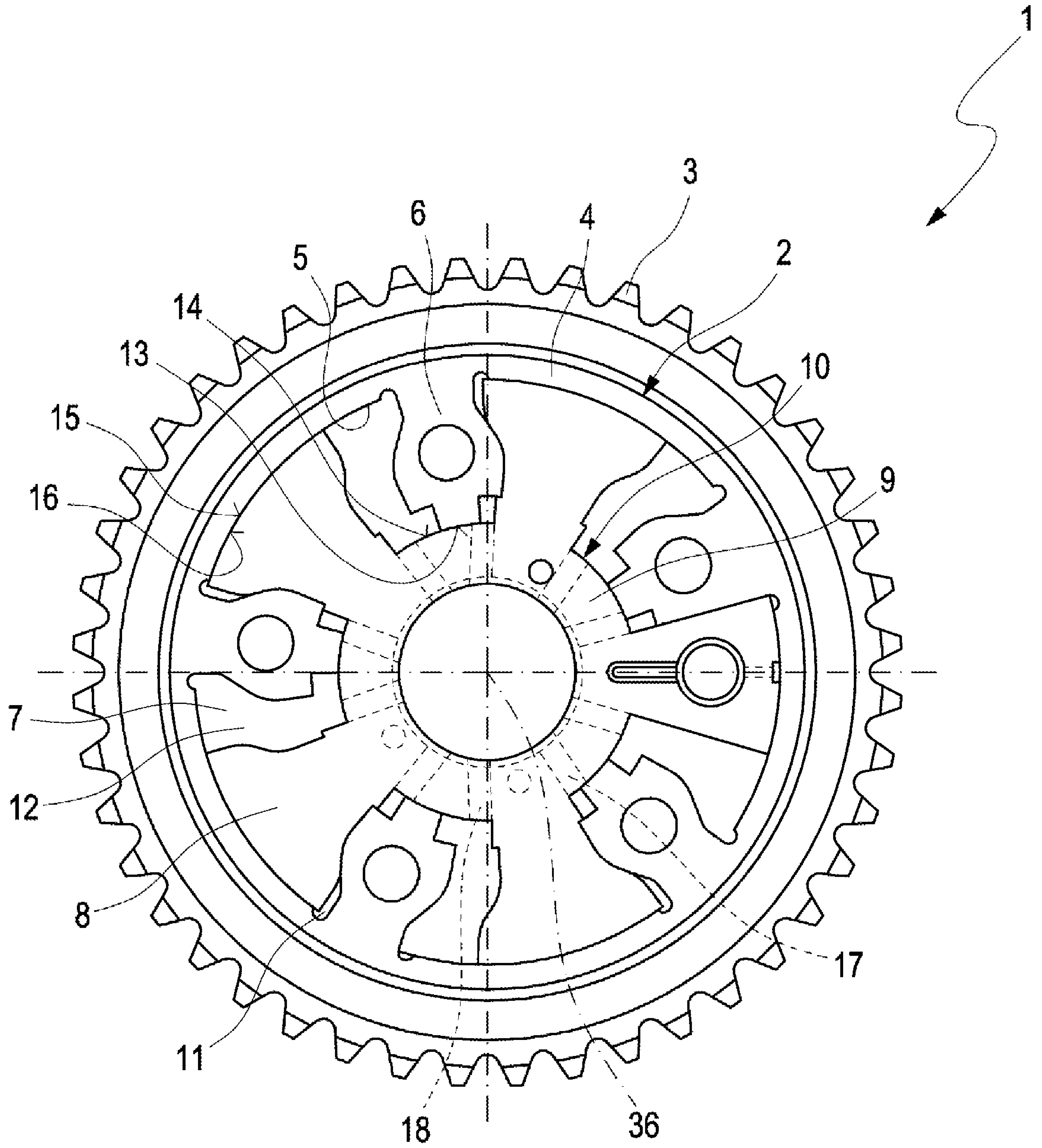
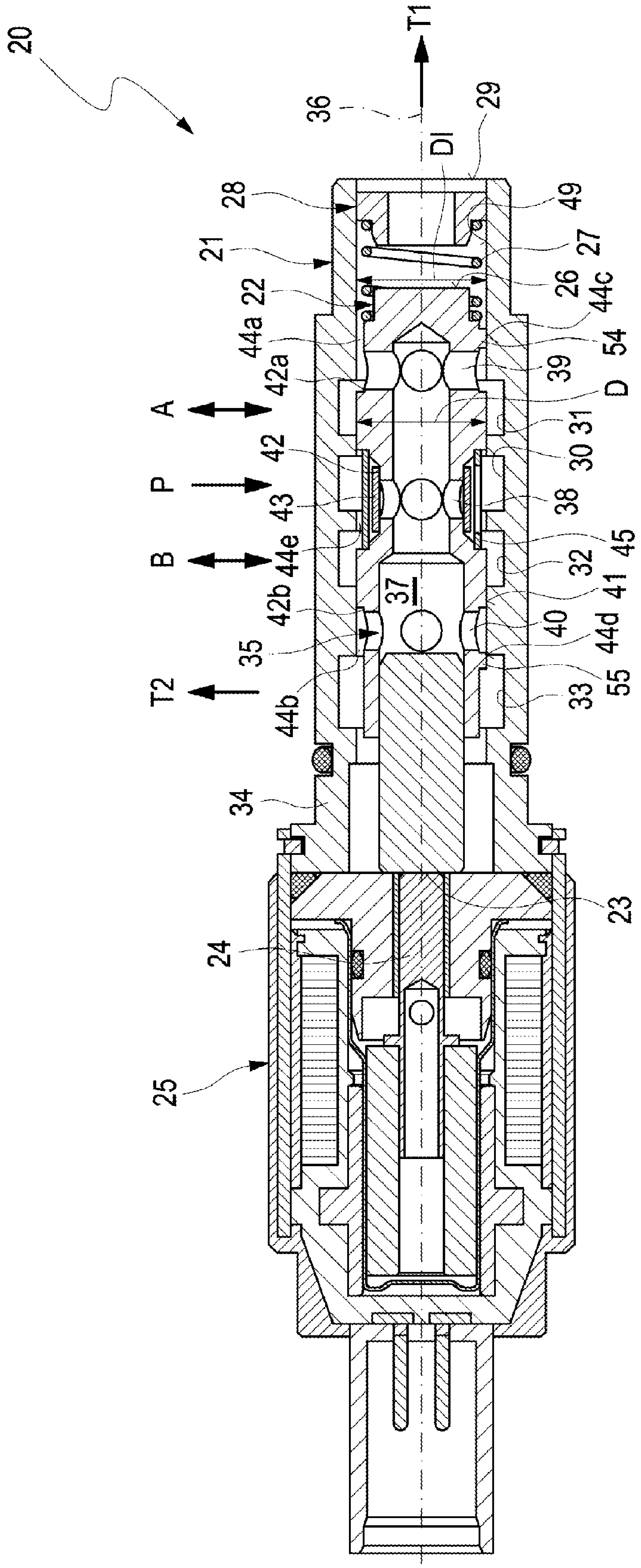


FIG. 1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T1
36
29
DI
28
49
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44a
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42
P
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43
44e
45
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32
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41
42b
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44d
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T2
33
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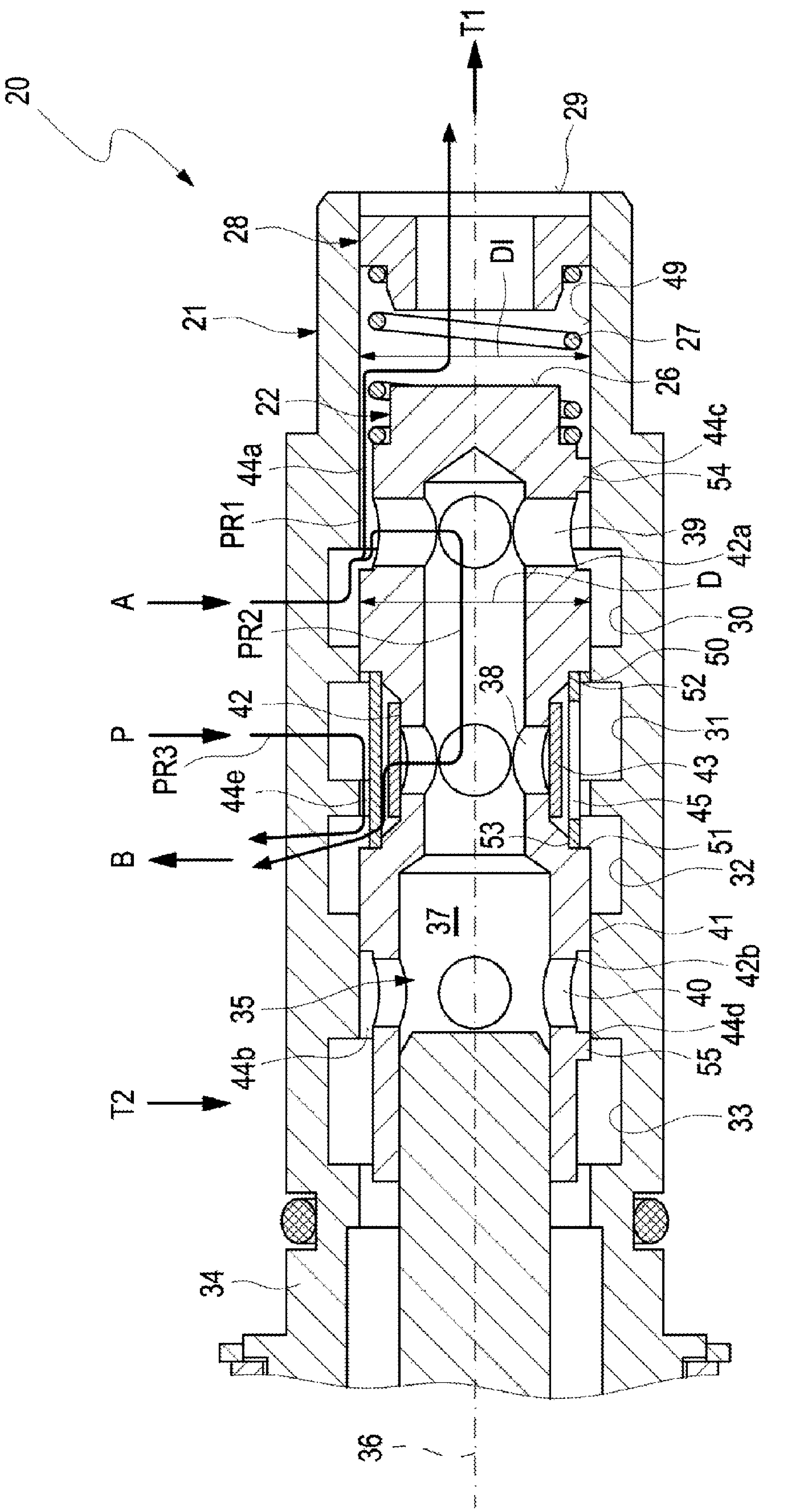
FIG. 2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20
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28
DI
49
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22
44c
44a
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PR1
39
42a
A
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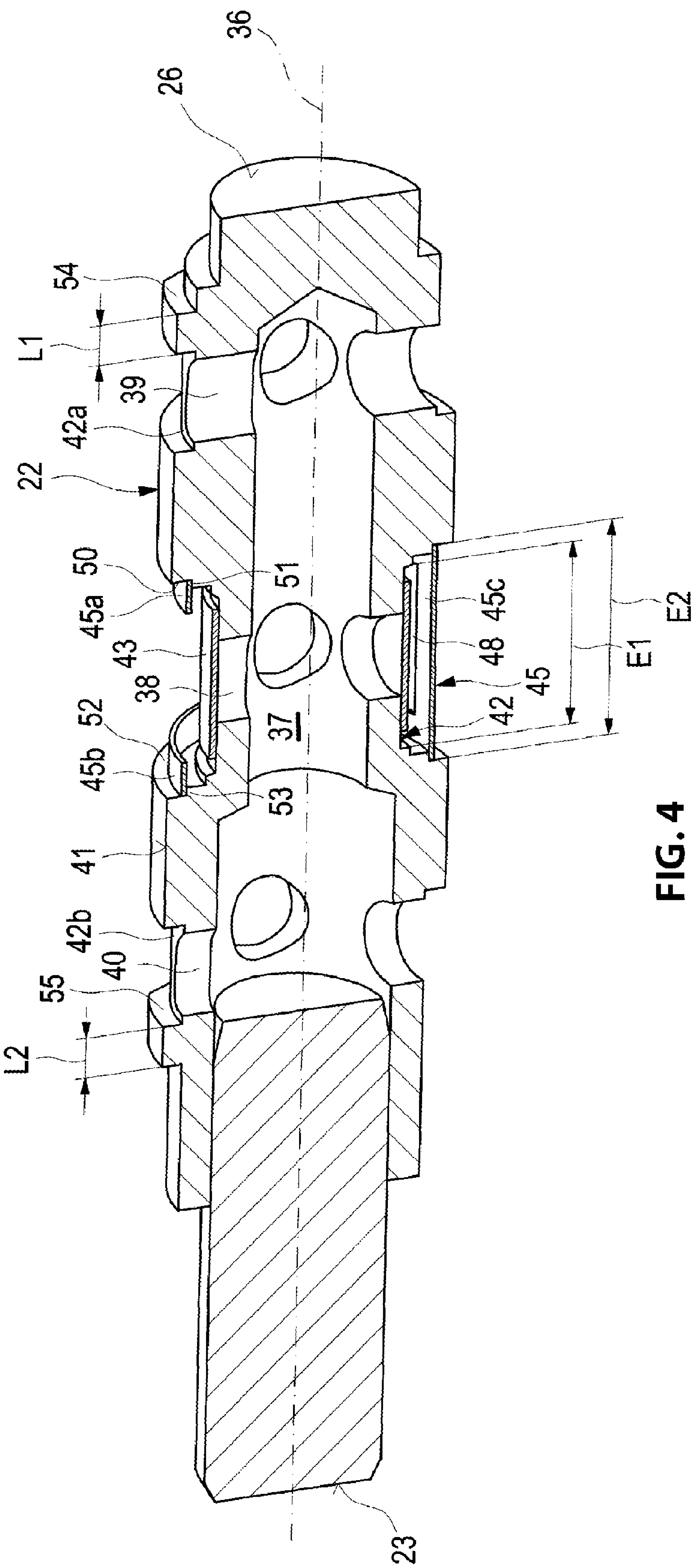
PR2
30
50
38
52
42
P
31
PR3
43
44e
45
51
B
53
32
41
37
42b
35
40
44d
55
44b
T2
33
34
36

FIG. 3


36
26
54
L1
39
42a
22
50
45a
43
38
52
45b
41
42b
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37
53
45c
48
45
42
E1
E2
23

FIG. 4

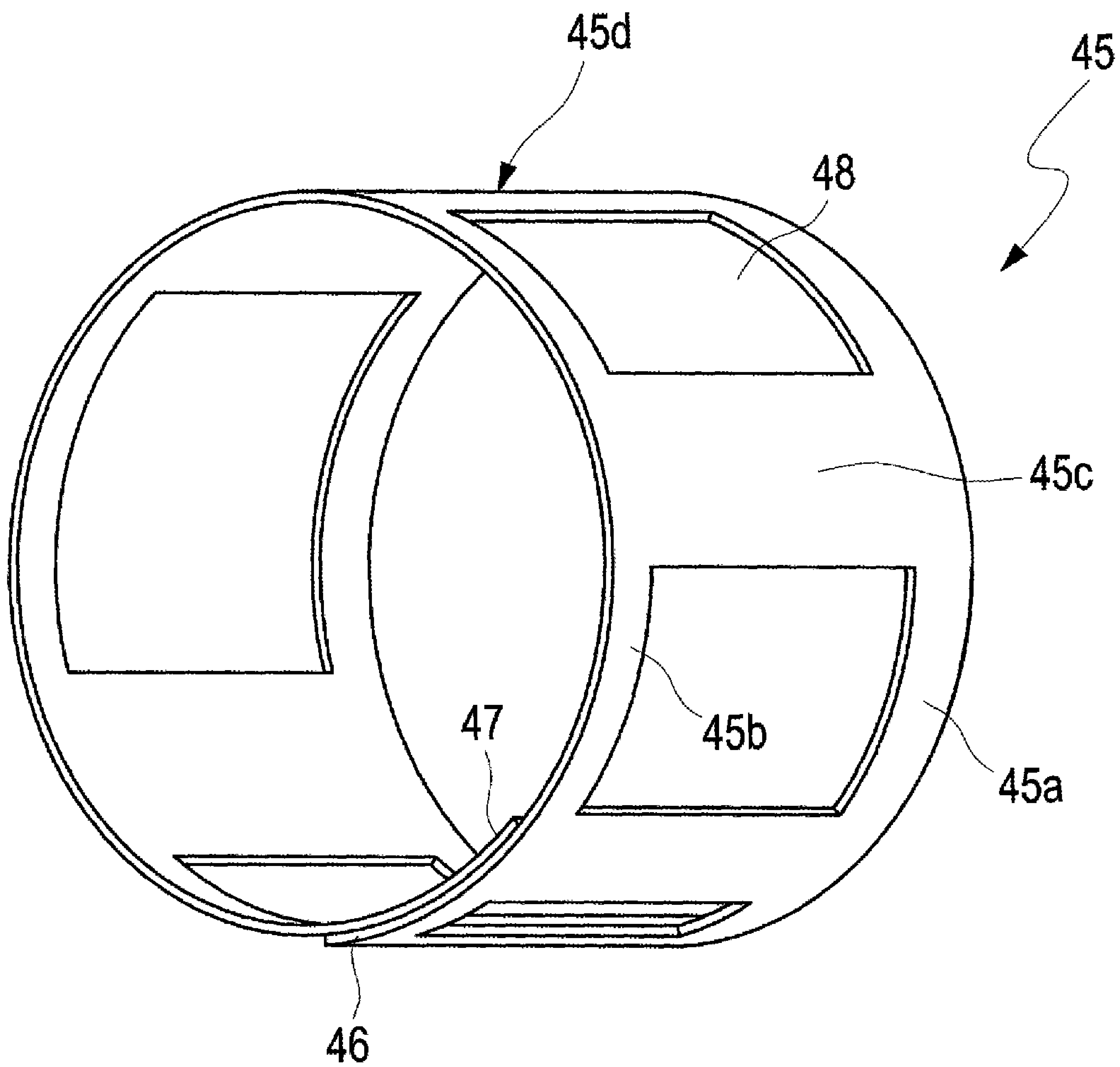

FIG. 5

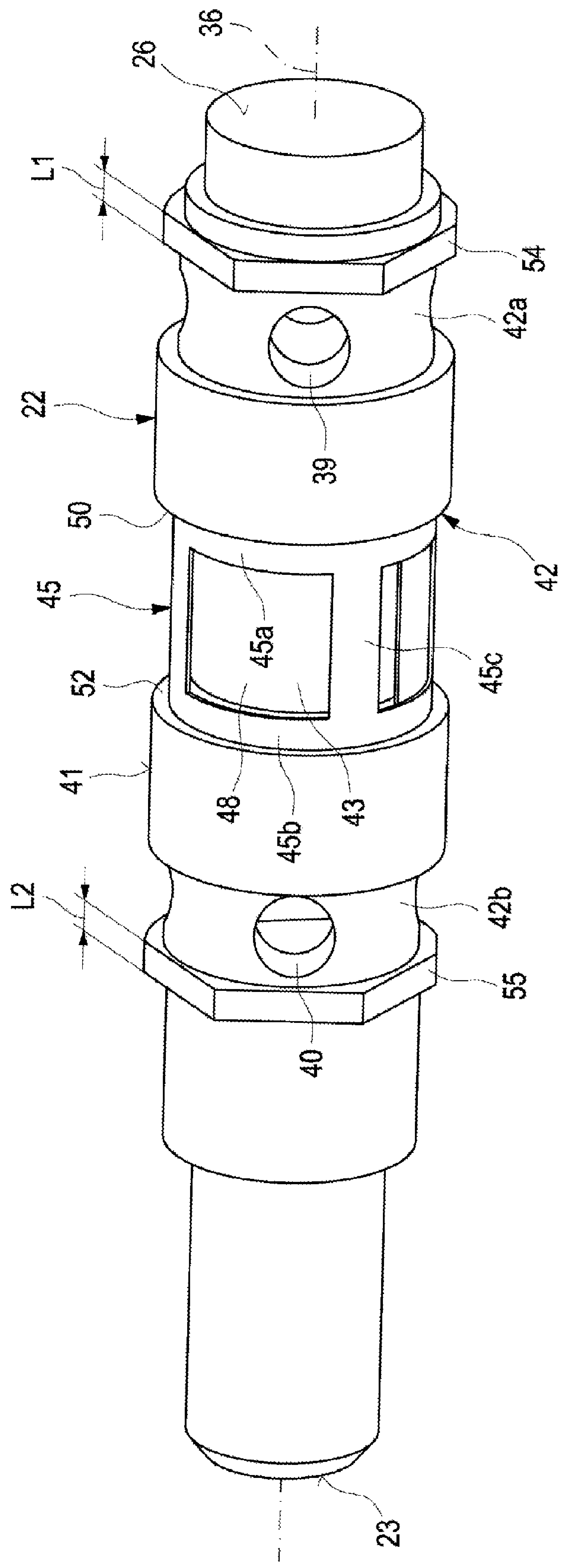

FIG. 6

HYDRAULIC VALVE FOR PIVOT MOTOR ADJUSTMENT DEVICE OF A CAMSHAFT

RELATED APPLICATIONS

This application claims priority from German patent application DE 10 2014 101 236.4 filed on Jan. 31, 2014 which is incorporated in its entirety by this reference.

FIELD OF THE INVENTION

The invention relates to a hydraulic valve for a pivot motor adjustment device of a camshaft according to the preamble of claim **1**.

BACKGROUND OF THE INVENTION

Hydraulic valves for pivot motor adjustment devices of a camshafts are well known in the art. Hydraulic valves include a valve piston that is axially moveable in a valve housing of the hydraulic valve. Typically the valve housing includes a first operating connection, a second operating connection and a supply connection. The first operating connection and the second operating connection are connected with the pivot motor adjustment device and a hydraulic fluid is feedable through these connections into the hydraulic valve and also from the hydraulic valve. In order to supply the hydraulic valve with the hydraulic fluid that is fed by a feed device the valve housing includes the supply connection. The hydraulic fluid can flow through the hydraulic valve in different paths controlled by a flowable channel system of the valve piston. In order to use a camshaft adjustment torques the hydraulic valve includes at least one check valve in the portion of the operating connections. Additionally a check valve is arranged in a flow portion of the supply connection. Thus, the check valves facilitate controlling the hydraulic fluid in the hydraulic valve as a function of a pressure.

Check valves for hydraulic valves whose closure elements are configured band shaped are also known. This can be derived from the French patent document FR 525 481 published in 1921 which discloses a check valve including a band shaped closure element.

The patent document DE 101 43 433 B4 discloses a band shaped closure element of a hydraulic valve wherein the closure element includes spring supported closure flaps.

A band shaped closure element of a check valve for a hydraulic valve can also be derived from the patent document EP 2 503 201 B1. The disclosed closure valve is characterized in that it includes a stop at a band end in order to limit its expansion. Since the closure element is only flowable within limits due to the stop different types of flow openings are provided.

The publication document US 2013 206 088 A1 discloses a hydraulic valve whose check valve is provided with a spring based closure element and received in the valve piston.

By the same token check valves with a band shaped closure elements for pivot motor adjustment devices for camshafts are known. The publication documents DE 10 2010 061 337 A1 and DE 10 2010 019 004 A1 disclose hydraulic valves with a band shaped closure element of the check valve. Contrary to the hydraulic valve known from DE 10 2010 061 337 A1 which respectively uses a check valve for the first operating connection and the second operating connection the hydraulic valve disclosed in DE 10 2010 019 004 A1 includes a single check valve through which the first operating connection and the second operating connection can be loaded as a function of a positioning of the valve piston that is axially

moveable in the valve housing of the hydraulic valve along a longitudinal axis of the valve housing. The operating connection and the second operating connection are thus axially offset from one another wherein the supply connection of the valve housing is arranged between the first operating connection and the second operating connection. In order to flow the hydraulic valve through ring grooves in the valve housing are associated with the connections.

The check valve is arranged at the valve piston in a positioning groove of the valve piston that is oriented towards the ring grooves wherein the positioning groove is connected with the channel system in a flowable manner wherein the valve piston is moveable in the valve housing. Due to the axial move ability of the valve piston there is an option to use the first check valve for both operating connections.

The hydraulic fluid can flow through the hydraulic valve on different paths determined by the flowable channel system wherein a first tank connection of the hydraulic valve is configured at the valve housing providing a drain for the hydraulic fluid out of the hydraulic valve.

In order to quickly adjust the camshaft a quick and unimpeded response of the hydraulic valve, put differently a quick axial movement of the valve piston in the valve housing is required. Thus, it is necessary that the closure element of the check valve does not contact the valve housing during operations of the pivot motor adjustment device.

BRIEF SUMMARY OF THE INVENTION

Thus, it is an object of the invention to provide a hydraulic valve for a pivot motor adjustment device of a camshaft which hydraulic valve provides improved response.

The object is achieved according to the invention through a hydraulic valve for a pivot motor adjustment device of a camshaft, the hydraulic valve including a valve housing with a longitudinal axis and a valve piston that is axially moveable in the valve housing along the longitudinal axis, wherein a first operating connection of the valve housing and a second operating connection of the valve housing is openable and closable by the valve piston, wherein the first operating connection and the second operating connection are axially offset from one another; and a supply connection of the valve housing, wherein the supply connection supplies the hydraulic valve with hydraulic fluid fed by a feed device, wherein the hydraulic fluid flows through the hydraulic valve on different paths defined by a flowable channel system of the valve piston, wherein a first tank connection of the hydraulic valve is configured at the valve housing and provides an outflow of the hydraulic fluid from the hydraulic valve, wherein a first check valve is positioned at the valve piston in a positioning groove of the valve piston so that the first check valve prevents an outflow of the hydraulic fluid from the positioning groove into the channel system, and wherein the hydraulic valve includes a limitation element at least partially enveloping the first check valve and limiting a radial expansion of the first check valve.

Advantageously embodiments with advantageous and non-trivial variations of the invention are provided in the respective dependent claims.

The hydraulic valve according to the invention for a pivot motor adjustment device of a camshaft includes a limitation element at least partially enveloping the check valve wherein the limitation element limits a radial expansion of the check valve. Through the at least partial envelopment of the check valve, in particular of a closure element of the check valve, the check valve is limited with respect to its radial expansion provided during operations of the hydraulic valve. This leads to improved and faster response of the hydraulic valve since a contact or a touching of the check valve at the valve housing is prevented.

The check valve is opened as a function of a pressure ratio provided at the check valve. Since the closure element of the check valve is band shaped, and the positioning groove is provided over its entire circumference the closure elements expands in radial direction as a function of the pressure ratio. Now put differently the closure element expands at least partially in a direction of the valve housing. The radial expansion is provided as a function of a provided pressure ratio. A high pressure ratio leads to a strong expansion. This means that the closure element can expand at least partially radially out of the positioning groove and that the closure element can contact an inner valve surface oriented towards the positioning groove or that it can touch this valve surface. This contact can lead to a damaging of the valve housing and/or to impeding an axial movement of the valve piston.

The limitation element prevents a respective contacting of the check element at the valve housing since the limitation element is configured so that it envelops the check element at least partially and therefore provides a resistance to the radial expansion of the check element.

In order to effectively limit the check element the limitation element is configured so that it is supported at the valve piston. Thus, the radial arrangement and also the axial arrangement of the limitation element relative to the check element is maintained in each position of the valve piston so that a touching or a contact of the check element or its closure element at the valve housing is safely prevented. Providing the limitation element at the valve housing would lead to a change of an axial arrangement relative to the stop element for an axial movement of the valve piston and the check element could contact the valve housing in a portion that is not enveloped by the limitation element.

Like the check valve the limitation element is arranged in the positioning groove of the valve piston. In order to provide a radial distance between the closure element of the check valve and the limitation element wherein the radial distance is required so that the check valve can open within this radial distance, the limitation element is received at a first shoulder and at a second shoulder of the positioning groove, wherein the shoulders are provided at walls of the positioning groove at a required radial distances from the closure element of the check valve.

In order for the hydraulic fluid to be able to flow in the direction released by the check valve the limitation element includes at least one pass through opening. Ideally pass through openings are arranged distributed over a circumference of the limitation element. These pass through openings have to be configured so that a flow resistance which is provided as a consequence by the limitation element in the flow path of the hydraulic fluid is as small as possible. This means that an effective flow cross section of the limitation element which is provided as a sum of the individual effective flow cross sections of the pass through openings should at least approximately correspond to the effective flow cross section of the positioning groove. This is necessary so that pressure losses or flow losses which can be caused by the limitation element are avoided to the largest possible extent.

In order to provide simple mounting for the limitation element the limitation element is made from a band. The band is introduced bent into the positioning groove so that it envelops the shoulders, thus with a small preload, wherein a first band portion of the band and a second band portion of the band are arranged overlapping in installed condition in order to produce the hollow cylindrical shape of the limitation element.

Advantageously a second tank connection of the hydraulic valve is configured at the valve housing so that a respective tank connection can be associated with the first operating connection and the second operating connection independently from one another.

In another embodiment of the hydraulic valve according to the invention the valve piston includes a throttling element for throttling a fluid drainage of the hydraulic fluid at the valve piston, in particular so that the throttle element envelops the valve piston over its radial circumference. Typically throttle elements are arranged at the valve housing in portions of faces of the valve piston. This arrangement leads to an axial force that impacts the accordingly loaded face of the valve piston. When the throttle element is configured as suggested at the valve piston, in particular at its circumference, the axial force is eliminated so that a position change of the valve piston in the hydraulic valve can be provided very quickly since the valve piston does not have to be moved against an axial force caused by the throttle element.

In a particularly economical embodiment the throttle element has a polygon shaped circumference. This polygon shaped circumference can be implemented in a simple manner e.g. through so called eccentrical turning.

The hydraulic valve is advantageously configured as a central valve so that reduced installation space and improved response are provided compared to an external hydraulic valve since conduction paths for the hydraulic fluid can be kept short.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional features and advantages of the invention can be derived from the subsequent description of advantageous embodiments with reference to appended drawing figures.

The features and feature combinations recited in the description and individual features and feature combinations recited in the description of the drawings and/or in the drawings and feature combinations are not only useable in the respectively provided combination but in also other combinations or by themselves without departing from the spirit and scope of the invention. Identical reference numerals are associated with identical or functionally equivalent elements. In order to provide clarity it may be the case that elements are not provided with numerals in all drawing figures, wherein:

FIG. **1** illustrates a cross section of a pivot motor adjustment device according to the invention;

FIG. **2** illustrates a longitudinal sectional view of a hydraulic valve according to the invention;

FIG. **3** illustrates a detail of a longitudinal sectional view of the hydraulic valve according to FIG. **2**;

FIG. **4** illustrates a three dimensional sectional view of a valve piston of the hydraulic valve according to FIG. **2**;

FIG. **5** illustrates a perspective view of a cage of the hydraulic valve according to FIG. **2**; and

FIG. **6** illustrates a perspective of the valve piston according to FIG. **4**.

DETAILED DESCRIPTION OF THE INVENTION

A pivot motor adjustment device **1** according to FIG. **1** facilitates adjusting opening and closing times of gas flow control valves of the internal combustion engine during operations of the internal combustion engine that is not illustrated in more detail. Thus, a relative angular position of a camshaft that is not illustrated in more detail of the internal combustion engine is adjusted continuously variable by the pivot adjustment motor device **1** relative to a crank shaft that is not illustrated in more detail of the internal combustion engine, wherein the camshaft is rotated relative to the crank shaft. A relative rotation of the crank shaft moves opening and closing times of the gas flow control valves so that the internal combustion engine provides optimum power at a respective speed.

The pivot motor adjustment device **1** includes a cylindrical stator **2** which is connected torque proof with a drive gear **3** of the camshaft. In the illustrated embodiment the drive gear **3** is a sprocket over which a non illustrated chain is run as a drive element. The drive gear **3** can also be a timing belt cog over which a timing belt is run forming a drive element. Through this drive element and the drive gear **3** the stator **2** is drive connected with the crank shaft.

The stator **2** includes a cylindrical stator base element **4** on which radially inward extending bars **6** are configured at even distances on an inside **5** wherein an intermediary cavity **7** is formed between two respectively adjacent bars **6**. A pressure medium, typically hydraulic fluid, is introduced in a controlled manner into this intermediary cavity **7**, through a hydraulic valve **20** that is illustrated in more detail in FIG. **2**.

A lobe **8** is positioned so that it protrudes into the intermediary cavity **7**, wherein the lobe is arranged at a rotor hub **9** of the rotor **10**. Corresponding to the number of intermediary cavities **7** the rotor hub **9** includes a number of lobes **8**.

Through the lobes **8** the intermediary cavities **7** are respectively divided into a first pressure cavity **11** and a second pressure cavity **12**. In order to reduce a pressure loss in the first pressure cavity **11** and the second pressure cavity **12**, the bars **6** are configured so that they contact an outer enveloping surface **14** of the rotor hub **9** with their first faces **13** providing a seal through the contact. By the same token the lobes **8** contact an inner wall **16** of the stator base element **4** with their second faces **15** wherein the inner wall **16** is positioned opposite to the outer enveloping surface **14** and a seal is provided through the contact.

The rotor **10** is connected torque proof with the camshaft of the internal combustion engine. In order to adjust an angular position between the camshaft and the crank shaft the rotor **10** is rotated relative to the stator **2**. For this purpose the pressure medium in the first pressure cavity or in the second pressure cavity **12** is pressurized as a function of a selected direction of rotation, whereas the second pressure cavity **12** or the first pressure cavity **11** is unloaded. The unloading is provided through a tank access which is opened for unloading. This can be a single tank access that is accessible to the first pressure cavity **11** and the second pressure cavity **12** or as illustrated in the embodiment according to FIG. **2** a first tank inlet T**1** is associated with the first pressure cavity **11** and a second tank access T**2** is associated with the second pressure cavity **12**.

In order to rotate the rotor **10** clock wise relative to the stator, radial first hub bore holes **17** are pressurized by the hydraulic valve **20** wherein the hub bore holes **17** are evenly distributed over a circumference of the rotor hub **9**. In order to rotate the rotor **10** relative to the stator **10** counter clockwise radially oriented second hub bore holes **18** are pressurized through the hydraulic valve **20** wherein the radially oriented second bore holes are also arranged distributed over the circumference of the rotor hub **9**, wherein the second hub bore holes **18** are positioned axially offset from the first hub bore holes **17**.

In FIG. **2** the hydraulic valve **20** according to the invention is illustrated in a longitudinal sectional view in a first valve position. The hydraulic valve **20** is configured similar to a cartridge valve and includes a valve housing **21** in which a valve piston is arranged axially moveable.

In order to move the valve piston **22** a first face **23** of the valve piston **22** that is oriented away from the internal combustion engine is closed so that a plunger **24** of an electromagnetic linear actuator **25** can contact this first face **23**. Providing power to the linear actuator **25** causes an axial movement of the valve piston **22** towards the internal combustion engine wherein a retaining element arranged at a second face **26** of the valve piston **22**, wherein second face **26** if oriented away from the first face **23**, imparts a retaining force onto the valve piston **22** against which retaining force the valve piston **22** has to be moved. The retaining element **27**, in this embodiment configured as a compression coil spring, is supported at a hollow cylinder **28** which is arranged with a press fit in the valve housing **21** in a portion of a housing face **29** that is oriented towards the internal combustion engine.

The sleeve shaped valve housing **21** includes a supply connection P, a first operating connection A and a second operating connection B. A first ring groove **30** is associated with the supply connection P a second ring groove **31** is associated with the first operating connection A and a third ring groove **32** is associated with the second operating connection B, wherein the respective ring grooves are connected with the connections through respective linking channels. The linking channels are configured so that they completely penetrate a housing wall **34** of the valve housing **21**.

The supply connection P is configured to connect with an oil pump that is not illustrated in mover detail, so that the hydraulic valve **20** is supplyable with the hydraulic fluid which is oil in this embodiment. The first operating connection A is connectable with the first hub bore holes **17**, the second operating connection B is connectable with the second hub bore holes **18**. The first tank access T**1** is arranged at the housing face wall **29**. The second tank access T**2** is connectable with a fourth ring groove **33** of the valve housing **21** which ring groove is axially offset from the supply connection B, wherein the connection can be provided through an additional linking channel that is not illustrated in more detail and which leads into the fourth ring groove **33**. The fourth ring groove **33** is arranged between the first face **23** and the third ring groove **32**.

The valve piston **22** is configured so that it can be flowed through and it includes a channel system **35** which can be flowed through by the hydraulic fluid. A supply channel **37** of the channel system **35** is provided along a longitudinal axis **36** of the valve piston **22**, wherein a first channel group **38**, a second channel group **39** and a third channel group **40** traverse the supply channel **37** respectively axially offset from one another. The first channel group **38**, the second channel group **39** and the third channel group **40** are flow connected with one another through the supply channel **37**, so that hydraulic fluid for example from the first channel group **38** can flow through the supply channel **37** into the second channel group **39** and/or the third channel group **40**. A channel group in this embodiment respectively includes two transversal bore holes that intersect each other and that are positioned perpendicular relative to one another, wherein the transversal bore holes are configured so that they extend over a diameter D of the valve piston **22** so that they penetrate the valve piston **22** in its entirety. By the same token the channel group could also include a different number of transversal bore holes.

At ends of a first channel group **38** which ends are oriented towards an enveloping surface **41** of the valve piston **22**, of the second channel group **39** and of the third channel group **40** the valve piston **22** respectively includes an annular groove, this means a positioning groove **42**, a fifth ring groove **42***a*, and a sixth ring groove **42***b* wherein the ends of the first channel group **38** lead into the positioning groove **42**, the ends of the second channel group **39** lead into the fifth ring groove **42***a* and the ends of the third channel group **40** lead into the sixth ring groove **42***b*. In the positioning groove **42** a first check valve **43** is received, whose closure element is configured band shaped. A check valve with a band shaped closure element is known and can be derived e.g. EP 1 703 184 B1. It is appreciated that a check valve per definition includes a housing and a closure element opening or closing the flow through opening of the housing. In case of a band shaped closure element walls that define the flow through opening can be used to form the housing for the band shaped closure element as illustrated in the embodiment. Therefore the first check valve **43** is subsequently interpreted as the closure element and vice versa.

The first closure element **43** prevents an inflow of the hydraulic fluid from the first ring groove **30**, from the second ring groove **31** and from the third ring groove **32** into the first channel group **38**. On the other hand side the first check valve **43** opens when hydraulic flows through the first channel group **38** from the supply channel **37**. Put differently, the first check valve **43** closes in a direction towards the supply channel **37** and opens in a direction towards the ring grooves **30**, **31**, **32**.

A second check valve **4** is provided outside of the valve housing **21** between the supply connection P and the oil pump in order to prevent a back flow of the hydraulic fluid into the oil pump.

The first valve position of the hydraulic valve **20** illustrated in FIG. **2** corresponds to a valve position in an unpowered condition of the linear actuator **25**. In this condition the fifth ring groove **42***a* at least partially covers the second ring groove **31**, so that the hydraulic fluid from the first pressure cavities **11** can flow through the first hub bore holes **17**, the first operating connection A and the second ring groove **31** into the fifth ring groove **42***a* and further into the second channel group **39**, provided a first pressure in the first pressure cavities **11** exceeds a second pressure that is provided in the channel system **35**. The hydraulic fluid flowing out of the second ring groove **31** is separated into a first fluid flow and second fluid flow while providing pressure compensation. The first fluid flow can flow out of the second ring groove **31** due to the partial overlap of the fifth ring groove **42***a* and the second ring groove **31** through a first gap **44***a* into the first tank access T**1** according to the arrow direction PR**1**, c.f. FIG. **3**, wherein the first gap **44***a* is configured in the portion between the second face **26** and the fifth ring groove **42***a* between the enveloping surface **41** and a valve inner surface **49** of the valve housing **21**. The gap **44***a* is configured in sections over the circumference of the valve piston **22**.

The second fluid flow flows according to the second arrow direction PR**2** into the second channel group **39** and from there into the supply channel **37** wherein the fluid flow moves into the third ring groove **32** through the first check valve **43**. The third ring groove **32** is covered in this valve position at least partially by the positioning groove **42**, so that the inflow of the hydraulic fluid from the first channel group **38** can be provided through the positioning groove **42** into the third ring groove **32**. The hydraulic fluid flowing out of the supply connection P onto the first check element **43** flows through a third gap **44***e* which is configured in the first valve position between the positioning groove **42** and the inner valve surface **49** according to the third arrow direction PR**3** into the third ring groove **32**.

The hydraulic fluid thus moves through the second operating connection B into the second hub bore holes **18** which are connected with the second pressure cavities **12**, so that the pressure in the second pressure cavities increases and the drive wheel **3** is rotated counter clock wise relative to the stator **2**.

As soon as the camshaft due to its switching torques tends to rotate into the intended adjustment direction, the pressure in the first pressure cavities **11** increases. When this pressure is large enough so that the preloaded first check valve opens sufficient hydraulic fluid is provided through the second operating connection B to the second pressure cavities **12** which have a suction effect due to a vacuum so that a rotation of the rotor **10** is provided. A fast rotation is provided that could not be provided by the oil pump alone.

A second valve position can be adjusted by providing power to the linear actuator **25**. The valve piston **22** is pushed into its end position against a force of the retaining element **27** in a direction towards the first tank access T**1**. In this end position the second face **26** contacts the hollow cylinder **28**. Thus the valve piston **22** was axially moved far enough so that the overlap of the fifth ring groove **42***a* and the second ring groove **31** is removed so that the second ring groove **31** is closed by the enveloping surface **41**.

Due to the axial movement of the valve piston **22**, an overlap is provided between the positioning groove **42** and the second ring groove **31** and the first ring groove **30** so that an overflow of the hydraulic fluid is provided from the supply connection P into the first operating connection A. Furthermore at least a partial overlap of the sixth ring groove **42***b* and the third ring groove **32** is provided. The hydraulic fluid which now flows from the second operating connection B separates into a third fluid flow and a fourth fluid flow, wherein the third fluid flow can enter the first channel groove **38** through the third channel group **40** and the supply channel **37**.

After opening the first check valve **43** the third fluid flow continues to flow from the positioning groove **42** into the second ring groove **31**. The fourth fluid flow flows through a second gap **44***b* that is configured between the valve inner surface **49** and the enveloping surface **41** into the second tank connection T**2**.

This context and the basic principle of the hydraulic valve **20** are also described in more detail in DE 10 2010 019 004 A1 so that they are not described herein in more detail.

FIG. **4** illustrates the valve piston **22** in a longitudinal sectional view along the longitudinal axis **36** in three dimensions. The positioning groove **42** is configured in steps so that in its radial extension a first shoulder **51** is configured at a first wall **50** that is oriented towards its first face **26** and a second shoulder **53** is configured at its second wall **52** that is arranged opposite to its first wall **50**, so that the positioning groove **42** has a first axial extension E**1** and a second axial extension E**2**, wherein the first axial extension E**1** is configured smaller than the second axial extension E**2**.

The first check valve **43** is received in the portion of the positioning groove **42** which has the first extension E**1**, wherein the first wall **50** and the second wall **52** are used for axially securing the check valve **43**. Axial end portions of the band shaped closure element of the check valve **43** overlap each other slightly so that an opening pressure can be kept small.

In order to limit a radial expansion of the check valve **43** or the closure element of the check valve **43** an annular limitation element **45** which envelops the check valve **43** is arranged at the valve piston **22**. The limitation element **45** is illustrated in more detail in a perspective view in FIG. **5**. The limitation element **45** is made from a band **45***d* which includes transversal struts **45***c* of the band **45***d* between a first longitudinal strut **45***a* of the band **45***d* and a second longitudinal strut **45***b* of the band **45***d*, wherein the transversal struts **45***c*, the first longitudinal strut **45***a* and the second longitudinal strut **45***b* are configured so that they connect with each other.

In order to position the limitation element **45** at the valve piston **22** and thus to envelop the first check valve **43** the band shaped limitation element **45** is bent so that a first band portion **46** and a second band portion **47** overlap one another and the band **45***d* contacts the valve piston **22** like a ring.

Between the transversal struts **45***c* and the longitudinal struts **45***a*, **45***b* pass through openings **48** of the limitation element **45** are configured rectangular for a free pass through of the hydraulic fluid in this embodiment.

The limitation element **45** can be also made from a band shaped perforated sheet material, to that the limitation element **45** that is provided with numerous pass through openings **48** is configured similar to a sieve. Additional modifications of the limitation element are conceivable, wherein the pass through openings **48** have to be configured so that a pressure loss which can be provided by the limitation element **45** in the flow path of the hydraulic fluid from the first channel group **38** into the positioning groove **44** is kept as small as possible or so that it is eliminated.

The limitation element **45** is arranged at the valve piston **22** so that it is supported at the first shoulder **51** and at the second shoulder **52** by the first longitudinal strut **45***a* or the second longitudinal strut **45**. Put differently the first longitudinal strut **45***a* and the second longitudinal strut **45***b* contact over their axial extension at least partially at the first shoulder **51** or the second shoulder **52** wherein the pass through openings **48** form a free flow cross section for the hydraulic fluid. A radial extension of the first check valve **43** is limited by the transversal struts **45***c*, so that a contact of the first check valve **43** or the closure element of the check valve **43** with the inner valve surface is prevented.

An implementation of throttling the flow of the hydraulic fluid into the first tank access T**1** without axial force and into the second tank access T**2** is provided with a first throttle element **54** or a second throttle element **55**. The first throttle element **54** is provided between the fifth ring groove **42***a* and the second face **26** adjacent to the fifth ring groove **42***a* and the second throttle element **45** is provided between the sixth ring groove **42***b* and the first face **23** adjacent to the sixth ring groove **42***b*. These throttle elements **54**, **55** completely envelop the radial circumference of the radial valve piston **22**.

The first throttle element **54** and the second throttle element **55** include a polygon shaped radial circumference c.f. in particular FIG. **6** so that over the radial circumference of the valve inner surface **49** alternatively the first gap **44***a* and a first seal surface **44***c* or the second gap **44***b* and the second seal surface **44***d* are configured by the first throttle element **54** or the second throttle element **55**.

The first throttle element **54** extends adjacent to the fifth ring groove **42***a* over an axial first length L**1** and the second throttle element **22***b* extends adjacent to the sixth ring groove **42***b* over an axial second length L**2**. In this embodiment the first length L**1** corresponds to the second length L**2**. By the same token the first length L**1** can deviate from the second length L**2**. The first length L**1** and the second length L**2** correspond to a desired throttle effect.

The polygon shaped radial circumference has the shape of a pentagon. It could also have the shape of another polygon wherein due to reducing the pressure loss the polygon shaped radial circumference of the first throttle element **54** and of the second throttle element **55** should not have less than 5 polygon edges. By the same token the number of the polygon edges should not exceed a certain number that is a function of the diameter D of the valve piston **22**. This would mean too little differentiation between the circular radial circumference of the valve piston **22** so that an outflow of the hydraulic fluid through the first tank connection T**1** and the second tank connection T**2** would be throttled too much. As illustrated in particular in FIGS. **2** and **3** the first gap **44***a* is provided by the first polygon shaped throttle element **54**. This first gap **44***a* does not extend over the entire radial circumference of the valve piston **22** but the first throttle element **54** partially contacts the valve inner surface **49**, thus the first gap **44***a* is only formed in sections.

In the portion of the sixth ring groove **42***b* a second gap **44***b* is implemented through the polygon shaped radial circumference of the second throttle element **55** so that the hydraulic fluid can Flow in a throttled manner from the third channel group **40** over the second gap **44***b* into the second tank access T**2**.

REFERENCE NUMERALS AND DESIGNATIONS

1 pivot motor adjustment device
2 stator
3 drive gear
4 stator base element
5 inner side
6 bar
7 intermediary cavity
8 lobe
9 rotor hub
10 rotor
11 first pressure cavity
12 second pressure cavity
13 first face
14 outer enveloping surface
15 second face
16 inner wall
17 first hub bore hole
18 second hub bore hole
20 hydraulic valve
21 valve housing
22 valve piston
23 first face
24 plunger
25 linear actuator
26 second face
27 retaining connection
28 hollow cylinder
29 housing face wall
30 first ring groove
31 second ring groove
32 third ring groove
33 ring groove
34 housing wall
35 channel system
36 longitudinal axis
37 supply channel
38 first channel group
39 second channel group
40 third channel group
41 enveloping surface
42 positioning groove
42*a* fifth ring groove
42*b* sixth ring groove
43 first check valve
44*a* first gap

44*b* second gap
44*c* first seal surface
44*d* second seal surface
44*e* third gap
45 limitation element
45*a* first longitudinal strut
45*b* second longitudinal strut
45*c* transversal strut
45*d* band
46 first band portion
47 second band portion
48 pass through opening
49 inner valve surface
50 first wall
51 first shoulder
52 second wall
53 second shoulder
54 first throttle element
55 second throttle element
A first operating connection
B second operating connection
D diameter
DI inner diameter
E**1** first axial extension
E**2** second axial extension
L**1** first length
L**2** second length
P supply connection
PR**1** first arrow direction
PR**2** second arrow direction
PR**3** third arrow direction
T**1** first tank access
T**2** second tank access

What is claimed is:

1. A hydraulic valve for a pivot motor adjustment device of a camshaft, the hydraulic valve comprising:

a valve housing with a longitudinal axis and a valve piston that is axially moveable in the valve housing along the longitudinal axis,

wherein a first operating connection of the valve housing and a second operating connection of the valve housing is openable and closable by the valve piston,

wherein the first operating connection and the second operating connection are axially offset from one another;

and a supply connection of the valve housing,

wherein the supply connection supplies the hydraulic valve with hydraulic fluid fed by a feed device,

wherein the hydraulic fluid flows through the hydraulic valve on different paths defined by a flowable channel system of the valve piston,

wherein a first tank connection of the hydraulic valve is configured at the valve housing and provides an outflow of the hydraulic fluid from the hydraulic valve,

wherein a first check valve is positioned at the valve piston in a positioning groove of the valve piston so that the first check valve prevents an outflow of the hydraulic fluid from the positioning groove into the channel system, and

wherein the hydraulic valve includes a limitation element at least partially enveloping the first check valve and limiting a radial expansion of the first check valve.

2. The hydraulic valve according to claim **1**, wherein the limitation element is supported at the valve piston.

3. The hydraulic valve according to claim **1**, wherein the valve piston includes a shoulder for positioning the limitation element.

4. The hydraulic valve according to claim **1**, wherein the limitation element is configured hollow cylindrical and includes at least one pass through opening that is arranged at its circumference.

5. The hydraulic valve according to claim **1**, wherein the limitation element is configured as a curved band.

6. The hydraulic valve according to claim **1**, wherein a first band portion of the band and a second band portion of the limitation element are arranged overlapping in an installed condition.

7. The hydraulic valve according to claim **1**, wherein a second tank connection of the hydraulic valve is configured at the valve housing.

8. The hydraulic valve according to claim **1**, wherein the valve piston includes a throttle element throttling a fluid outflow of the hydraulic fluid.

9. The hydraulic valve according to claim **8**, wherein the throttle element provides a gap for a fluid outflow of the hydraulic fluid in sections between an inner valve surface of the valve housing and an enveloping surface of the valve piston.

10. The hydraulic valve according to claim **8**, wherein the throttle element has a polygon shaped radial circumference.

11. The hydraulic valve according to claim **1**, wherein the hydraulic valve is configured as a central valve of a pivot motor adjustment device.

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